Seasonal and regional variations of five heavy metals in water, sediments and fishes inhabiting Lake Qarun, Egypt

A. Y. H. Elwasify [1], M. H. Ghanem [2], M. M. M. El-Bamby [1,*] and F. A. F. Ali [3]

[1] *Department of Environment and Bio-Agriculture, Faculty of Agriculture (Cairo), Al-Azhar University, Egypt*

[2] *Department of Ecophysiology-Zoology, Faculty of Science, (Cairo), Al-Azhar University, Egypt*

[3] *Department of Plant Protection, Faculty of Agriculture (Cairo), Al-Azhar University, Egypt*

* Correspondence: Melbamby76@azhar.edu.eg (M. El-Bamby)

ABSTRACT

The study was conducted during the period from October 2015 to September 2016 to investigate the accumulation of five heavy metals in three fish species (*Tilapia zillii, Solea solea* and *Mugil cephalus*) inhabiting lake Qarun, Egypt. Water, sediments and fish samples were collected from six sites cover eastern, middle and western sectors of the lake during the four studied seasons. The results indicated that, summer time showed the highest pH, salinity, biological oxygen demand and nitrates concentration, while autumn and spring times showed the highest nitrites concentration depending on the site. The abundance of metals in lake water, sediments and fish followed the order: Fe > Zn ≈ Mn > Cu > Cd. In all fish species Fe and Zn exceeded the permissible limits. Regardless fish species, the highest concentrations of metals were recorded in fish liver, while the lowest in fish muscles. Mugil species seemed to be more contaminated with metals than the other species. It is recommended to coordinate different efforts to rescue Lake Qarun from heavy metal pollution.

Keywords: Egypt; Fishes Inhabiting; Heavy metal pollution; Lake Qarun; Sediments; Water.

INTRODUCTION

Lake Qarun is located in the western desert in the deepest part of Fayoum depression and lies 83 Km south west of Cairo. Lake Qarun attracts attention of many researchers because of its historical and scientifically importance to study its unique ecosystem. The description of the lake ecosystem, climatic conditions and sources of pollution were previously published (Authman and Abbas 2007; Hussein *et al.*, 2008; Abdel Satar *et al.*, 2010; Ibrahim and Ramzy, 2013; Tayel *et al.*, 2013). For example, Authman and Abbas, (2007) reported that most of agricultural drainage water reaches the lake by two main drains, El-Batts and El-Wadi. There are minor drains poured its drainage water into the lake by means of hydraulic pumps but in small amounts.

The present study was conducted to get recent information about the seasonal and regional distribution of heavy metals in the lake components (Water, sediments and inhabiting fishes). So, on the basis of previous and current results, one can allow the buildup of a meaningful database that can be used for comparative assessment and trend delineation.

MATERIALS AND METHODS

Study Area

Six stations or sites were selected to cover eastern, middle and western sectors of Lake Qarun (two sites / sector). The selection was determined by using Geographic Position System model 53. Fig. (1) shows the sampling locations.

Sampling

Samples of lake water, sediments and fish were collected during the period from October, 2015 to September, 2016. Surface water samples were collected by Ruttner bottle water sampler with capacity of 1-2 L. Samples for dissolved oxygen were collected in oxygen bottle (300 ml capacity). The other water samples were collected in polyethylene bottles for measuring other physicochemical parameters and heavy metals concentrations. Sediments samples were collected using Van Veen type, grab. Three fish species (*Tilapia zillii, Solea solea* and Mugil sp.) which are the most common fishes in the lake and widely consumed were caught. A total number of 180 adult fish of each species were collected per season with the help of local fishermen, then dissected freshly and their parts were stored on ice.

Measurements

Air and water temperatures were measured directly by using mercury thermometer graduated to 100°C. Hydrogen ion concentration (pH) was measured directly by using pH-meter model (Jenway 3150) after calibration with buffer solution. Salinity of water was determined by using salino-meter (Beckman; model RSAS) after calibration. Dissolved oxygen, biological oxygen demand, nitrite, nitrate concentrations were determined according to (APHA, 1995). Concentrations of heavy metals in water, sediments and fish were measured using inductively coupled plasma optical emission spectrophotometer (model 3400 DV, Perkin Elmer, Shelton, USA) according to standard methods of (APHA, 1995). Statistically, results were expressed in tables as mean ± S.D. Data were analyzed by using correlation coefficient for environmental factors and the interaction between the concentration of heavy metals in both water, sediment and target organs according to Bailey (1981).

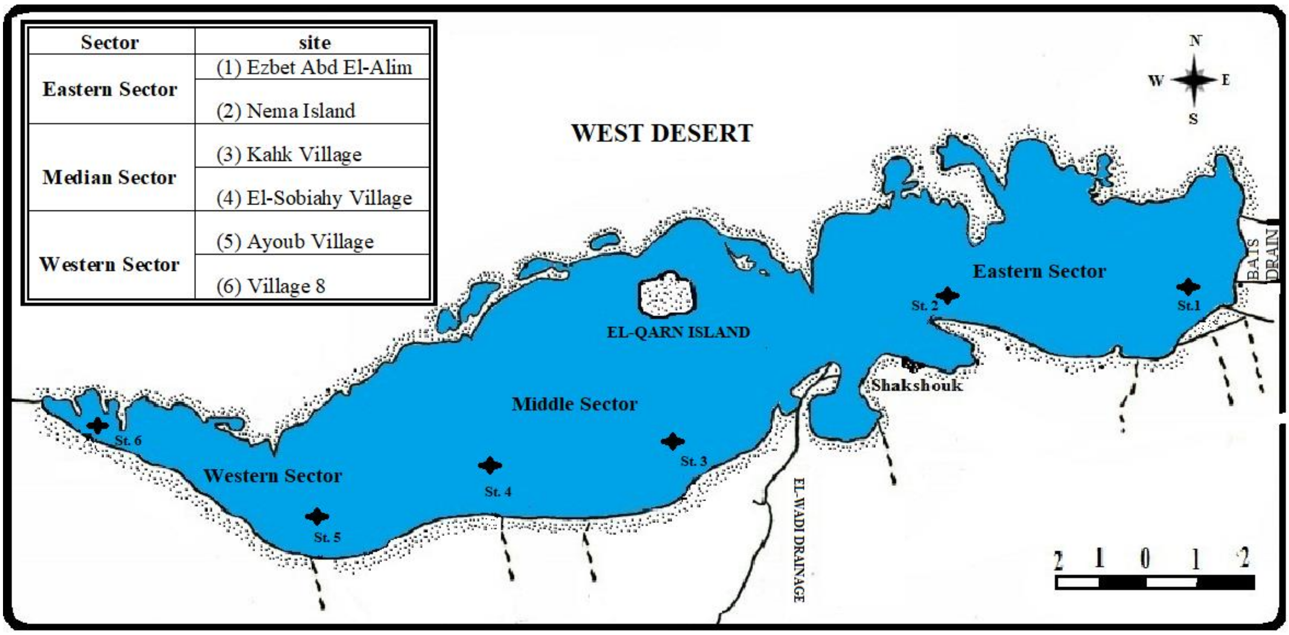

Fig. 1. Map of Lake Qarun showing the sampling location.

RESULTS AND DISCUSSION

Physicochemical parameters of lake water

Table (1) shows seasonal variation of many physicochemical parameters obtained from the six sites of the lake during the four studied seasons. Air and water temperature was measured in the field and showed significant differences among seasons. They increased during summer, while winter sustained the lowest values at most sites. Air and water temperature ranged between 24 - 36, 18 - 33 °C, respectively. These values are in the neighborhood of those obtained previously (Afifi, 2015 and Ragab, 2017). Afify *et al.* (2019) reported that there is no clear thermal stratified recorded in the lake due to shallowness of the lake (4 m depth is average) and it is considered being homoeothermic in nature. Changes in water temperature may ulter or inhibit normal growth and development of certain organisms including fishes (Salem, 2006).

Lake water showed moderately an alkaline character with pH values ranging between 8.15 - 8.95 which is in the neighborhood of that obtained by Khalil *et al*. (2017) and in the range of permissible limits (WHO, 1993). Lake water salinity were 35.05, 46.35‰ for the minimum and maximum value, respectively. Abdel Satar *et al.* 2010 reported that salinity in 1953 was 21.94%. this value was fluctuated from increase and decrease thereafter depending on the rate of evaporation, amount of drained waters and consumption of lake salts by Egyptian company of salts and minerals (EMISAL). The values of lake water salinity listed in Table (1) are approximately the same as obtained lay Ragab (2017). Thus, Haroon *et al.* (2018) cited that lake Qarun is considered saline water.

Dissolved oxygen (DO) was found to be fluctuated and ranged between 7.65 and 13.68 mg/L which is in the range of permissible limits (WHO, 1993). However, the range of Do obtained by Shaaban *et al.* (2016) and Khalil *et al.* (2017) were less than that listed in Table (1) Adequate dissolved O_2 is vital for the survival of aquatic organisms and is therefore an important variable in the assessment and monitoring of water quality. The relatively low concentration of DO recorded could be attributed to the fall in water temperature, phytoplankton blooming and exhaustion of DO for oxidation of huge amounts of organic matter discharged into the lake (Tayel *et al.,* 2013). The results for BOD (which is the amount of DO required to degrade certain amount of organic matter present in water) were ranged from 3.85 - 11.1 mg/L. which is in the neighborhood of that obtained by Khalil *et al.* (2017). The high concentration of BOD may be due to the high load of wastes discharged into the lake (Saad *et al.*, 2011).

The obtained values of nitrite ranged between 6.90-30.46 µg/L which are above the permissible limits many times. Approximate value of nitrite was obtained by Sadrin *et al.* (2016). Nitrite is considered the major pollutant threaten the health of aquatic organisms and its high level may be attributed to the decomposition of organic matter present in waste water by nitrosomonas bacteria which oxidize ammonia to nitrite (Saad *et al.*, 2011). Nitrate concentration fluctuated within the range of 186.80 to 584.50 µg/L and these values are higher than the corresponding values of nitrite due to fast conversion of NO_2 to NO_3 by nitrifying bacteria (Abdel Satar *et al.*, 2010). Nitrate is relatively non-toxic to fish and its level is below the permissible limit. The low values in nitrate concentration might be due to uptake of nitrate by phytoplankton and its reduction by denitrifying bacteria and biological denitrification (Abdo, 2002). Statistical analysis indicated a strong positive correlation between water and air temperatures, pH with air and water temperatures, Salinity with air & water temperatures as well as pH value. Also, positive correlation between BOD with DO (Table, 2).

Table 1. Seasonal variations of many physicochemical parameters (Mean ± S.D.) of Lake Qarun water at different sectors, during the period from autumn, 2015 to summer, 2016.

Sectors	Parameters / Seasons	Air Temp. (°C)	Water Temp. (°C)	pH	Salinity (‰)	DO (mg/L)	BOD (mg/L)	NO_2 (µg/L)	NO_3 (µg/L)
Eastern Sector	Autumn	25.75±2.07	23.45±1.40	8.15±0.29	35.75±1.16	8.05±1.51	4.20±1.22	19.69±2.67	377.50±88.77
	Winter	24.75±1.37	18.80±1.42	8.15±0.43	36.80±1.16	7.65±1.21	3.95±1.45	15.99±2.99	210.10±66.60
	Spring	29.35±1.48	26.00±1.44	8.28±0.29	39.40±1.20	7.95±1.24	3.85±1.22	20.20±2.56	186.80±35.66
	Summer	32.75±1.13	30.05±1.72	8.76±0.50	41.70±1.05	7.92±1.35	7.25±1.33	6.90±3.10	406.00±69.39
Middle Sector	Autumn	27.00±1.59	25.10±1.77	8.20±0.50	35.05±1.46	8.36±1.24	4.53±1.25	30.07±2.99	488.00±90.04
	Winter	26.50±1.08	19.75±1.40	8.25±0.29	36.85±1.16	11.00±1.41	6.75±1.12	23.06±3.05	394.10±72.22
	Spring	29.20±1.78	27.20±1.54	8.60±0.155	40.80±1.13	10.82±1.19	4.50±1.14	18.51±2.66	347.45±55.87
	Summer	35.00±1.21	31.80±1.61	8.85±0.28	42.45±1.54	9.06±1.37	6.92±1.10	8.75±3.00	516.50±80.51
Western Sector	Autumn	29.50±1.44	27.40±1.38	8.50±0.55	39.95±1.16	13.68±1.37	8.98±1.13	30.46±2.67	506.00±97.23
	Winter	26.80±1.29	23.05±1.77	8.40±0.50	37.85±1.13	11.70±1.21	7.00±1.22	14.81±2.99	316.45±63.54
	Spring	30.00±1.92	28.25±1.38	8.75±0.29	41.40±1.51	10.90±1.67	5.65±1.15	11.78±2.99	319.65±45.78
	Summer	36.35±1.49	33.70±1.45	8.95±0.16	46.35±1.36	10.48±1.24	11.10±1.11	10.64±3.17	584.50±77.98

Table 2. Correlation coefficient of the environmental factors in the water of Lake Qarun.

E. F.	Air Temp.	Water Temp.	pH	Salinity	DO	BOD	NO_2	NO_3
Air Temp.	1							
Water Temp.	0.93	1						
pH	0.88	0.86	1					
Salinity	0.53	0.55	0.65	1				
DO	0.11	0.15	0.31	0.39	1			
BOD	0.45	0.43	0.48	0.25	0.66	1		
NO_2	-0.41	-0.34	-0.53	-0.33	0.04	-0.24	1	
NO_3	0.44	0.45	0.35	-0.14	-0.08	0.12	0.25	1

Heavy metals

Among the myriad pollutants released into aquatic eco-systems, heavy metals have received considerable attention due to their toxicity, long-term persistence, bioaccumulation and biomagnification at various trophic levels (Ololade *et al.*, 2008).

Metals in Lake Qarun water occur in particulate or soluble form. Soluble species include labile and non-labile fractions. The labile metal compounds are the most dangerous to fish.

The presence of metals in the lake may be due to surplus discharges from agriculture drainage, sewage and various industrial effluents released into the lake, beside diverse natural processes such as erosion and weathering. However, anthropogenic activities remain the main cause of metal existence in lake water.

Seasonal variations of many heavy metals concentrations in water and sediment of Lake Qarun during the period from Autumn 2015 to Summer, 2016 are presented in Table (3).

Metals concentrations in lake water and sediments followed an abundance of Fe > Mn ≅ Zn > cu > Cd. Cd and Cu concentrations in lake water are below the permissible limits, while Fe, Mn and Zn concentrations are above the permissible limits (U. S. EPA., 2006).

Table (3) indicate that seasonal and regional variations affected the distribution of heavy metals in lake water and sediments. Generally, eastern sector showed an increased values of heavy metals (especially Mn and Zn concentrations) than other sectors. Similar findings were recorded by Ali and Fishar (2005) who reported that Fe & Mn are observed onto the surface of suspended particles. Therefore, their concentrations increased in the east lake side where the organic matter are more drained from El-Batts drain. Previous studies (Abdel Satar *et al.,* 2010 and Abou El-Gheit *et al.,* 2012) have confirmed the existence of lofty heavy metal pollutions in Lake Qarun water, however, the level of many metals in the current study exceeded the earlier reports indicating recent and increasing pollution events in the lake. Table (4) shows the correlation coefficient between some heavy metals in water and sediment of the lake. It is clear that, there are strong positive correlation between the concentration of iron and copper in the lake water, in addition to the same trend between the concentration of manganese in the water and cadmium, iron in the sediment. Furthermore, a strong positive correlation was showed between the concentration of zinc in the water and all the measured metals in the sediment, plus the concentration of each metal in the sediment with other metals.

Table (5) shows the concentration of heavy metals in different organs of the three studied fish species. Regardless the fish species, the lower concentrations of metals were recorded in fish muscles, while the higher values were in the liver. These findings are in agreement with those obtained previously (Mohamed and Gad 2008; Ibrahim and Ramzy 2013; Omar *et al.,* 2013). High concentration of metals in the liver are related to its detoxification, transformation and storage of toxic materials. Furthermore, metals are bound in liver to specific polypeptides, i.e., metallothioneins (Jezierska 2001). Data listed in Table (5) indicate that fish liver and kidney contained considerable amounts of heavy metals, so it is advisable to throw down the fish viscera before human consumption. The lowest bioaccumulated of heavy metals in muscles may be correlated with low fat-content and little blood supply to the muscular tissue. Statistically, Table (6) indicates a positive correlation between the concentration of Cd in the sediment and it's concentration in the gills of *S. solea*. For *M. cephalus* there are strong positive correlations between Cu & Zn in the sediment with their concentrations in the gills. Same trend was found between Fe & Mn concentrations in the sediment and their concentration in the kidney of the same sp. There for, data listed in Table 5 & 6 indicate that Mugil sp. Seemed to be more contaminated with metals than *Tilapia* and *Soliea* sp. Ali and Fishar (2005) reported that the concentrations of trace metals in fish samples indicated that *Solea* sp. seemed to be more contaminated than other fish species followed by Mugil sp. and *Tilapia sp*.

The difference in the pattern of metals distribution in the three studied fish species might be a result of their difference in many factors such as, feeding habitats, habitats, ecological needs, metabolism and physiology (Arellano *et al.,* 1999).

Data listed in Tables 3 and 5 indicate that concentrations of metals in sediments and fishes are more than their corresponding concentrations in water. For example, Zn concentrations in water, sediments and *Tilapia* fishes are 250 μg/L, 44.60 μg/g and 57.72 μg/g, respectively, which means that Zn concentrations in sediments and in *Tilapia* fish is about 178 and 230 times more than that found in water.

Heavy metals when discharged into water can enter the food chain, bioaccumulated in fish tissue and hence become threat to man.

Ravera *et al.,* 2003 postulated that pollutants concentrations in the organism are the result of the past as well as the recent pollution level of the environment in which the organism lives, while the pollutants concentrations in the water only indicate the situation at the time of sampling.

CONCLUSIONS

From the above findings, it is clear that, Lake Qarun is suffering from various pollution types which leads to affect water and aquatic organisms in the lake, furthermore, some of studied metals exceed the permissible limits with the great dangerous impact on fishes and human health. Distribution of heavy metals in the organs of studied fish species might be a result of many factors such as, feeding habitats, metabolism and physiology. Gills act as the target organ for cadmium and manganese, while copper, iron and zinc prefers accumulate in the liver than other organs. It is recommended that, water quality of the lake must be protected and improved as soon as possible. The following measured may be suggested and taken into consideration. First, a prior treatment for industrial wastewater must be enforced contentiously and domestic sewage must be treated before discharging. Second, the agriculture waste must be managed to reduce the pollutions in the lake.

Table 3. Seasonal variations of some heavy metals concentrations in the water and sediment of Lake Qarun, during the period from autumn, 2015 to summer, 2016.

Sectors		Eastern Sector					Middle Sector					Western Sector				
Seasons		Autumn	Winter	Spring	Summer	average	Autumn	Winter	Spring	Summer	average	Autumn	Winter	Spring	Summer	average
Water, µg/L	Cd	0.88 ± 0.19	0.88 ± 0.13	0.92 ± 0.23	0.81 ± 0.15	0.87 ± 0.17	0.84 ± 0.13	0.74 ± 0.13	0.92 ± 0.23	0.94 ± 0.20	0.86 ± 0.17	0.78 ± 0.13	0.68 ± 0.13	0.78 ± 0.12	1.05 ± 0.29	0.82 ± 0.17
	Cu	64.20 ± 5.05	69.70 ± 6.26	56.50 ± 8.14	43.60 ± 3.77	58.50 ± 5.8•	74.05 ± 7.66	51.90 ± 4.35	54.90 ± 5.50	57.50 ± 6.14	59.60 ± 5.91	55.90 ± 5.58	41.60 ± 4.67	36.80 ± 3.16	53.10 ± 6.05	46.80 ± 4.86
	Fe	639.00 ± 109.00	312.00 ± 40.90	391.00 ± 37.40	261.00 ± 19.80	401.00 ± 51.70	700.00 ± 90.40	418.00 ± 57.10	276.90 ± 22.00	346.00 ± 42.20	435.00 ± 53.00	280.00 ± 31.10	390.00 ± 26.90	295.00 ± 14.50	308.00 ± 26.40	318.00 ± 24.70
	Mn	311.00 ± 24.30	262.00 ± 15.60	182.00 ± 21.60	254.00 ± 10.60	252.00 ± 18.00	181.00 ± 14.10	159.00 ± 12.20	109.00 ± 8.73	388.00 ± 21.00	210.00 ± 14.00	200.00 ± 19.70	245.00 ± 50.10	236.00 ± 14.10	364.00 ± 52.40	261.00 ± 34.10
	Zn	261.00 ± 7.13	316.00 ± 16.30	340.00 ± 12.10	369.00 ± 13.40	321.00 ± 12.20	169.60 ± 13.00	321.00 ± 18.80	127.00 ± 8.16	301.00 ± 14.60	230.00 ± 13.60	205.00 ± 16.80	147.00 ± 10.10	186.00 ± 12.70	258.00 ± 15.70	199.00 ± 13.80
Sediments, µg/g dry wt	Cd	1.28 ± 0.24	1.57 ± 0.15	1.21 ± 0.16	1.70 ± 0.22	1.44 ± 0.19	0.86 ± 0.07	0.58 ± 0.03	0.58 ± 0.08	1.57 ± 0.37	0.90 ± 0.13	0.94 ± 0.08	0.77 ± 0.12	1.31 ± 0.17	0.79 ± 0.14	0.95 ± 0.12
	Cu	21.40 ± 2.68	18.70 ± 2.67	20.00 ± 3.09	23.54 ± 4.03	20.90 ± 3.12	9.44 ± 1.95	6.99 ± 1.14	6.52 ± 1.05	19.50 ± 3.16	10.60 ± 1.82	10.10 ± 2.15	5.72 ± 1.09	9.06 ± 1.59	8.53 ± 1.23	8.36 ± 1.51
	Fe	3634.00 ± 60.00	3918.00 ± 67.90	3555.00 ± 73.00	4053.00 ± 104.00	3700 ± 76.00	3214.00 ± 58.00	2937.00 ± 35.00	2930.00 ± 99.00	3915.00 ± 80.00	3249.00 ± 66.00	3297.00 ± 80.00	3119.00 ± 57.00	3664.00 ± 83.00	3142.00 ± 74.00	3305.00 ± 73.00
	Mn	511.00 ± 104.00	425.00 ± 66.30	447.20 ± 46.00	453.00 ± 32.80	459.00 ± 62.20	279.00 ± 56.20	226.00 ± 25.20	234.00 ± 10.20	365.00 ± 15.30	276.00 ± 26.70	294.00 ± 19.00	187.00 ± 12.60	202.00 ± 11.90	238.00 ± 16.10	230.00 ± 14.90
	Zn	53.90 ± 1.96	76.50 ± 3.52	70.30 ± 4.53	53.30 ± 3.35	63.50 ± 3.34	44.40 ± 3.63	19.80 ± 1.44	27.30 ± 1.68	44.70 ± 4.40	34.00 ± 2.79	31.10 ± 2.16	28.10 ± 2.39	51.10 ± 2.72	35.20 ± 2.45	36.40 ± 2.43

Note: Overall mean of Zn conc. in lake water = (321+230+199)/3 = 250 µg/L ≅ 0.25 µg/g; Overall mean of Zn conc. in lake sediment = (63.5+34.0+36.4)/3 = 44.6 µg/g

Table 4. Correlation coefficient between some heavy metals in the water and sediment of Lake Qarun.

Heavy metals		Water					Sediments				
		Cd	Cu	Fe	Mn	Zn	Cd	Cu	Fe	Mn	Zn
Water	Cd	1									
	Cu	0.40	1								
	Fe	-0.04	0.60	1							
	Mn	0.41	-0.03	-0.04	1						
	Zn	0.23	0.12	-0.11	0.31	1					
Sediments	Cd	0.15	0.05	-0.14	0.50	0.63	1				
	Cu	0.30	0.27	0.07	0.39	0.77	0.87	1			
	Fe	0.14	0.05	-0.14	0.50	0.63	0.99	0.87	1		
	Mn	0.31	0.43	0.21	0.26	0.71	0.74	0.96	0.74	1	
	Zn	0.29	0.32	0.07	0.23	0.55	0.80	0.79	0.80	0.77	1

Table 5. Seasonal variations of some heavy metals concentrations (µg/g wet wt.) in the target organs of *T. zillii*, *S. solea* and *M. cephalus* collected from Lake Qarun during the period from autumn, 2015 to summer, 2016.

Metals	Fish	*T. zillii*					S. *solea*					*M. cephalus*				
	Seasons	Gills	Kidney	Liver	Muscles	Average	Gills	Kidney	Liver	Muscles	Average	Gills	Kidney	Liver	Muscles	Average
Cd	Autumn	0.210±0.016	0.130±0.008	0.100±0.011	0.060±0.007	0.125±0.011	0.190±0.004	0.080±0.004	0.110±0.003	0.060±0.013	0.110±0.006	0.130±0.001	0.080±0.002	0.090±0.001	0.050±0.013	0.088±0.004
	Winter	0.130±0.003	0.100±0.008	0.110±0.013	0.090±0.016	0.108±0.010	0.190±0.016	0.180±0.019	0.130±0.002	0.120±0.019	0.155±0.014	0.160±0.002	0.090±0.016	0.150±0.013	0.060±0.002	0.115±0.008
	Spring	0.300±0.016	0.300±0.010	0.400±0.019	0.260±0.011	0.315±0.014	0.160±0.006	0.150±0.009	0.180±0.006	0.140±0.003	0.158±0.006	0.200±0.007	0.110±0.030	0.180±0.016	0.100±0.013	0.148±0.017
	Summer	0.130±0.009	0.120±0.003	0.150±0.008	0.110±0.017	0.128±0.009	0.100±0.007	0.180±0.011	0.090±0.004	0.070±0.004	0.110±0.007	0.150±0.002	0.080±0.009	0.140±0.006	0.060±0.004	0.108±0.005
	Average	0.193±0.010	0.163±0.007	0.190±0.013	0.130±0.013	0.169±0.011	0.160±0.008	0.148±0.011	0.128±0.004	0.098±0.009	0.133±0.008	0.160±0.003	0.090±0.014	0.140±0.009	0.068±0.008	0.114±0.009
Cu	Autumn	4.600±0.380	5.640±0.470	8.200±0.680	3.010±0.250	5.363±0.445	4.400±0.360	5.450±0.450	9.510±0.790	3.390±0.280	5.688±0.478	7.210±0.590	5.810±0.480	17.67±1.460	3.950±0.330	8.660±0.715
	Winter	5.060±0.420	6.680±0.550	17.01±1.410	3.180±0.260	7.983±0.660	5.920±0.480	7.340±0.600	13.44±1.110	3.760±0.310	7.615±0.625	5.160±0.430	7.670±0.630	28.79±2.380	4.860±0.400	11.62±0.960
	Spring	4.860±0.400	6.090±0.500	8.850±0.730	3.270±0.270	5.768±0.475	6.240±0.520	7.830±0.650	18.69±1.540	4.030±0.330	9.198±0.760	6.530±0.540	8.960±0.740	25.32±2.090	3.340±0.280	11.01±0.913
	Summer	5.710±0.470	5.150±0.430	10.46±0.870	3.480±0.290	6.200±0.515	4.030±0.330	3.980±0.320	9.880±0.810	4.220±0.340	5.528±0.450	5.737±0.470	7.050±0.580	32.25±2.660	4.730±0.390	12.44±1.030
	Average	5.058±0.420	5.890±0.488	11.13±0.923	3.235±0.268	6.328±0.523	5.148±0.423	6.150±0.505	12.88±1.063	3.850±0.315	7.007±0.576	6.159±0.505	7.373±0.608	26.01±2.150	4.220±0.350	10.94±0.903
Fe	Autumn	382.1±31.60	173.3±14.31	204.8±16.92	113.3±9.360	218.4±18.04	120.4±9.940	183.5±15.16	232.8±19.23	70.25±5.800	151.7±12.53	361.7±29.89	256.7±21.21	444.5±36.73	109.4±9.030	293.1±24.22
	Winter	445.5±36.82	215.5±17.81	478.6±39.54	91.27±7.540	307.7±25.43	106.0±8.750	144.5±11.92	215.0±17.77	77.75±6.420	135.8±11.22	213.9±17.68	179.0±14.79	350.0±28.92	109.5±9.050	213.1±17.61
	Spring	317.6±26.24	207.4±17.14	261.8±21.63	145.1±11.99	233.0±19.25	196.2±16.22	267.1±22.07	272.9±22.55	87.57±7.240	205.9±17.02	247.5±20.45	185.6±15.33	513.4±42.42	103.4±8.530	262.5±21.68
	Summer	354.0±29.26	171.2±14.15	305.3±25.23	131.5±10.86	240.5±19.88	114.8±9.490	180.2±14.88	243.1±20.08	76.27±6.300	153.6±12.69	345.4±28.55	141.1±11.65	346.5±28.63	118.4±9.780	237.8±19.65
	Average	374.8±30.90	191.8±15.80	312.6±25.83	120.3±9.930	249.9±20.65	134.4±11.10	193.7±16.00	240.9±19.90	77.96±6.440	161.8±13.36	292.2±24.10	190.6±15.75	413.6±34.20	110.1±9.100	251.6±20.79
Mn	Autumn	15.25±1.160	5.530±0.440	15.85±1.210	2.490±0.180	9.780±0.748	10.36±0.840	2.860±0.290	3.330±0.250	2.220±0.160	4.693±0.385	31.17±2.380	3.350±0.250	5.170±0.390	2.710±0.200	10.60±0.805
	Winter	27.27±2.080	5.280±0.400	14.76±1.130	2.740±0.210	12.51±0.955	18.70±1.430	3.210±0.250	3.460±0.260	2.050±0.150	6.855±0.523	15.53±1.190	6.360±0.490	5.050±0.380	2.720±0.210	7.415±0.568
	Spring	13.20±1.010	6.050±0.460	10.53±0.800	2.850±0.220	8.158±0.623	20.15±1.540	2.610±0.200	4.590±0.350	2.490±0.190	7.460±0.570	17.96±1.370	4.310±0.330	5.020±0.380	3.670±0.280	7.740±0.590
	Summer	15.46±1.180	7.870±0.600	16.315±1.25	3.150±0.240	10.70±0.818	15.19±1.150	3.920±0.290	3.510±0.270	2.530±0.190	6.288±0.475	29.75±2.270	6.300±0.480	8.890±0.680	3.690±0.280	12.16±0.928
	Average	17.79±1.358	6.183±0.475	14.36±1.098	2.808±0.212	10.29±0.786	16.10±1.240	3.150±0.258	3.723±0.283	2.323±0.173	6.324±0.488	23.60±1.803	5.080±0.388	6.033±0.458	3.198±0.240	9.478±0.723
Zn	Autumn	50.00±4.210	35.46±2.980	86.36±7.260	36.64±3.080	52.11±4.383	55.21±4.640	40.23±3.380	86.95±7.310	24.16±2.030	51.64±4.340	54.83±4.610	26.45±2.220	90.22±7.590	20.45±1.720	47.99±4.035
	Winter	28.41±2.390	39.11±3.290	84.11±7.080	19.61±1.650	42.81±3.603	50.52±4.250	45.01±3.780	89.68±7.540	15.17±1.280	50.10±4.213	36.64±3.080	39.25±3.300	53.19±4.470	16.73±1.410	36.45±3.065
	Spring	77.09±6.480	63.72±5.360	102.8±8.650	44.46±3.740	72.02±6.058	54.49±4.580	38.55±3.240	65.21±5.480	46.92±3.950	51.29±4.312	41.92±3.520	51.18±4.300	55.21±4.640	18.38±1.540	41.67±3.500
	Summer	63.40±5.330	62.04±5.220	90.76±7.630	39.50±3.320	63.93±5.375	72.49±6.100	37.58±3.160	92.18±7.750	34.06±2.860	59.08±4.968	46.52±3.910	48.39±4.070	85.13±7.160	34.72±2.920	53.69±4.515
	Average	54.73±4.603	50.08±4.213	91.01±7.655	35.05±2.948	57.72±4.854	58.18±4.893	40.35±3.390	83.51±7.020	30.08±2.530	53.03±4.458	44.98±3.780	41.32±3.473	70.94±5.965	22.57±1.898	44.95±3.779

Table 6. Correlation coefficient of some heavy metals between sediment and three inhabiting fishes at Lake Qarun.

Fish species	*T. zillii*				S. *solea*				*M. cephalus*			
Organs Metals	Gills	Kidney	Liver	Muscles	Gills	Kidney	Liver	Muscles	Gills	Kidney	Liver	Muscles
Cd	0.22	-0.17	-0.37	-0.47	0.65	-0.95	-0.14	-0.48	-0.58	-0.34	-0.81	-0.45
Cu	-0.89	0.22	-0.21	-0.98	-0.01	0.19	-0.21	-0.98	0.65	-0.54	-0.94	-0.32
Fe	0.19	-0.34	-0.50	-0.30	-0.17	-0.12	-0.26	-0.63	0.45	0.98	0.32	-0.27
Mn	0.01	-0.75	0.10	-0.98	-0.59	-0.12	-0.28	-0.57	0.21	0.98	-0.70	-0.77
Zn	-0.27	-0.72	-0.49	-0.01	-0.18	0.06	0.31	-0.41	0.83	-0.93	0.68	-0.14

REFRENCES

Abdel-Satar, A.M., Goher, M.E., Sayed, M.F., 2010. Recent environmental changes in water and sediment quality of Lake Qarun, Egypt. J. Fish Aquatic Sci. 5 (2), 56-69.

Abdo, M.H., 2002. Environmental Studies on Rossetta Branch and Some Chemical Application in the Area Extended from EL-Kanater EL-Khyria to Kafr-Zayat City. Ph.D. Thesis, Fac. Sci. Ain Shams Univ., Cairo.

Abou El-Gheit, E.N., Abdo, M.H., Mahmoud, S.A., 2012. Impacts of blooming phenomenon on water quality and fishes in Qarun Lake, Egypt. Int. J. Environ. Sci. Eng. 3, 11- 24.

Afifi, M.A.M., 2015. Ecological and Biological Studies on Pipe Fish in Lake Qarun. M.Sc. Thesis, Zool. Dept., Fac. Sci., Al-Azhar Univ., Cairo, pp. 264.

Afify, D.G., Tahoun, U.M., Abdo, M.H., 2019. water quality index and microbial assessment of Lake Qarun, El-Batts and El-Wadi Drains, Fayoum Province, Egypt. J. Egypt. Aquatic Biol. Fisher. 23 (1), 341-357.

Ali, M.H., Fishar, M.R.A. 2005. Accumulation of trace metals in some benthic invertebrate and fish species relevant to their concentration in water and sediment of Lake Qarun, Egypt. J. Aquatic Res. 31, 289-301.

APHA, 1995. Standard Methods for the Examination of water and wastewater. 19th ed., American Public Health Association, Washington D.C.

Arellano, J.M., Storch, V., Sarasquete, C., 1999. Histological changes and copper accumulation in liver and gills of the senegales sole, *Solea senegalensis*. Ecotoxicol. Environ. Saf. 44 (1), 62-72.

Authman, M.M.N., Abbas, H., 2007. Accumulation and distribution of copper and zinc in both water and some vital tissues of two fish species (Tilapia and *Mugil cephalus*) of Lake Qarun, Fayoum Province, Egypt. Pak. J. Biol. Sci. 10 (13), 2105-2122.

Bailey, N.T., 1981. Statistical Methods in Biology. 2nd ed. Hodder and Stoughton, London, pp. 216.

Haroon, A.M., Hussian, A.M., El-Sayed, S.M., 2018. Deviations in the biochemical structure of some macroalgal species and their relation to the environmental conditions in Qarun Lake, Egypt J. Egypt. Aquatic Res. 44 (1), 15-20.

Hussein H, Amer, R., Gaballah, A., Refaat, Y., Abdel-Wahab, A., 2008. Pollution monitoring for Lake Qarun. Adv. Environ. Biol. 2 (2), 70-80.

Ibrahim, L.A., Ramzy, E.M., 2013. Water quality and its impact on *Tilapia zilli* (case study) Qarun Lake-Egypt. Int. Water Technol. J. 3 (4), 170-191.

Jezierska, B., Witeska, M., 2001. Metal Toxicity to Fish. University of Podlasie, Siedlce, Poland.

Khalil, M.T., Fishar, M.R., Shakir, S.H., Amer, A.S., Nassif, M.G., 2017. Impact of drainage water on macrobenthos structure of Lake Qaroun, (El-Fayoum, Egypt). Egypt. J. Aquatic. Boil. Fish. 21 (2), 17-32.

Mohamed, F.A.S. Gad, N.S. 2008. Environmental Pollution - Induced biochemical changes in tissues of *T. zilli*, *S. vulagris* and *M. capito* from Lake Qarun, Egypt. Global Vet. 2 (6), 327-336.

Ololade, I.A., Lajide, L., Amoo, I.A., Oladojo, N.A., 2008. Investigation of heavy metals contamination of edible marine seafood. Afr. J. Pure Appl. Chem. 2, 121-131.

Omar, W.A., Zaghloul, K.H., Abdel-Khalek, A.A., Abo-Hegab, S., 2013. Risk assessment and toxic effects of metal pollution in two cultured and wild fish species from highly degraded aquatic habitats. Arch. Environ. Contam. Toxicol. 65, 753-764.

Ragab, A.M.M., 2017. Biological Studies On Some Bony Fishes with Special Reference to Their Feeding Habits and Nutritional Values. M.Sc. Thesis, Zool. Dept, Fac. Sci., Al-Azhar Univ., Cairo.

Ravera, R.C., Beone, G.M., Dantos, M., Lodigiani, P., 2003. Trace element concentrations in fresh water mussels and macrophytes as related to those in their environment. J. Limnol. 62 (1), 61-70.

Saad, S.M., El-Deeb, A.E., Tayel, S.I., Ahmed, N.A.M., 2011. Haematological and histopathological studies on *Clarias gariepinus* in relation to water quality along Rosetta branch, River Nile, Egypt. J. Exp. Biol. (Zool.), 7 (2), 223-233.

Salem, T.A., 2006. Impact of Water Quality on the Biodiversity among Certain Sectors of the River Nile, Egypt. M.Sc. Ain Shams Univ., Cairo, pp. 189.

Shaaban, M.T., Ibrahim, H.A.H., Hanafi, A.A.M., 2016. Distribution of bacteria in Lake Qarun, AL Fayoum, Egypt (2014 -2015) in relation to its physical and hydrochemical characterization J. Biosci. Appl. Res. 9 (2), 601-615.

Shadrin, N.V., EL-Shabrawy, G.M., Anufriieva, E.V., Goher, M.E., Ragab, E., 2016. Long-term changes of physicochemical parameters and benthos in Lake Qarun (Egypt): Can we make a correct forecast of ecosystem future؟ Knowl. Manag. Aquat. Ec. 417, 18.

Tayel, S.I., Ibrahim S.A., Mahmoud S.A., 2013. Histopathological and muscle composition studies on *Tilapia zillii* in relation to water quality of lake Qarun, Egypt. J. Appl. Sci. Res. 9 (6), 3857-3872.

U.S. EPA., 2006. National Recommended Water Quality Criteria; Office of Water, Office of Science and Technology, United States Environmental Protection Agency, Washington, DC, pp. 5.

WHO, 1993. Evaluation of Certain Food Additives and Contaminates (Forty-first report of joint FAO/WHO export committee on food Additives). Technical Report Series NO. 837, World Health Organization, Geneva.

التغيرات الموسمية والمكانية لخمسة من المعادن الثقيلة في الماء والرواسب والاسماك المجمعة من بحيرة قارون- مصر

احمد ياسين هاشم محمد الوصيفي [١]، محمد حامد محمد غانم [٢]، محمود محمد محمد البمبي [١]، فؤاد احمد فهمي علي [٣]

[١] *قسم البيئة والزراعة الحيوية، كلية الزراعة بالقاهرة، جامعة الازهر، القاهرة، مصر*

[٢] *قسم الحيوان، كلية العلوم بنين بالقاهرة، جامعة الازهر، القاهرة، مصر*

[٣] *قسم وقاية النبات، كلية الزراعة بالقاهرة، جامعة الازهر، القاهرة، مصر*

الملخص العربي

تعتبر بحيرة قارون احد اهم البحيرات المصرية، حيث تتميز بعوامل مناخية جعلتها موطنا ملائما للعديد من الطيور المهاجرة. وبالرغم من هذه العوامل الفريدة فقد تعرضت البحيرة الى الاهمال الشديد والذي تمثل في صرف العديد من المخلفات الصلبة والسائلة (الصرف الصحي والزراعي لمحافظة الفيوم) على حد سواء. يعتمد تراكم العناصر الثقيلة داخل الكائنات الحية القاطنة لمياه البحيرة على كلا من تركيز العناصر، عمر الاسماك بالبحيرة وسلوكها الغذائي. لذا فقد تم اجراء الدراسة خلال الفترة من اكتوبر، ٢٠١٥ الى سبتمبر ٢٠١٦م، لرصد وتقييم معدل التراكم الحيوي لخمسة من اخطر العناصر الثقيلة في نوعين من الاسماك (سمكة موسى واسماك البوري الاصيل) القاطنة لبحيرة قارون، مصر. حيث تم تجميع كلا من عينات المياه ورسوبيات القاع من ستة مواقع تغطي انحاء البحيرة (القطاع الشرقي، الاوسط والغربي) خلال مدة الدراسة. سجلت اعلى قيمة لدرجة حرارة كلا من الماء والهواء خلال فصل الصيف، كما سجل اعلى معدل للاس الهيدروجيني، درجة الملوحة، الاكسجين المستهلك حيويا وكذلك تركيز النترات خلال نفس الموسم، في حين سجل موسم الخريف اعلى تركيز للنيتريت. اظهر عنصر الحديد اعلى تركيز داخل مياه ورسوبيات واسماك البحيرة مقارنة بباقي العناصر، بينما سجل عنصر الكادميوم اقل تركيز على الاطلاق. اوضحت الدراسة تجاوز عنصري الحديد والزنك الحدود المسموح بها داخل الاعضاء المستهدفة من اسماك الدراسة. كما اظهرت النتائج اقل معدل لترسيب العناصر داخل عضلات الاسماك. بينما سجل عنصري الكادميوم والمنجنيز اعلى معدل ترسيب لهما داخل خياشيم الاسماك. كما بينت النتائج اختيارية كلا من النحاس، الحديد والزنك لاكباد الاسماك عن باقي الاعضاء. اشارت النتائج الى ارتفاع تركيزات العناصر الثقيلة داخل الاعضاء المختلفة لاسماك البوري عن اسماك موسى باستثناء عنصري الكادميوم والزنك. اظهرت التحاليل الاحصائية وجود ارتباط قوى (ايجابي) بين تركيز عنصر الكادميوم في رسوبيات بحيرة قارون وخياشيم اسماك موسى. كما اوضحت الدراسة وجود ارتباط ايجابي بين تركيز عنصري النحاس والزنك في رسوبيات البحيرة وتركيزهما داخل خياشيم اسماك البوري. كما اوصت الدراسة بضرورة تنسيق كافة الجهود الممكنة للحد من ارتفاع معدلات التلوث داخل بحيرة قارون والعمل على تحسين جودة مياهها.